Chapter

Technological Solutions and Specific Equipment for Improving the Degraded Grasslands by Total Reseeding

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Abstract

The scientific basis and the development of research on new solutions for organic production of fodder and their conversion into animal products with high biological value, maintaining biodiversity and environmental protection, have created the premises for promoting new technologies to improve, rehabilitate and enhance the grasslands, which are in accordance with a sustainable and efficient agriculture practice. In this chapter the technological solutions and technical equipment for improving the permanent grasslands by total renovation, specific to each stationary area conditions, are presented. The basis of new technologies or technological sequences for improving the degraded grasslands is composition and utilization of complex aggregates, consisting of specific machines and equipment, using the recent research achievements in the field of grassland farming. It is also intended that the proposed technological solutions eliminate or limit the effect of external restrictive factors so as to ensure a high feed production and a high feed value, meeting the agrotechnical requirements for each agricultural component operation. For highlighting the advantages of using the specific machines, traditional technologies, within are used common farming machines and new technologies, when are used specific machinery for grassland farming, are analyzed in comparison. To improve the degraded grasslands by reseeding method, new technologies and technological sequences use different complex aggregates, which perform in a pass 2 or even 3 operations, such as: clearing of non-valuable vegetation, hillocks and liming; tillage and liming; seedbed preparation and spreading the chemical fertilizers; rolling before sowing, sowing, rolling after sowing; the destruction of the old grass carpet, seedbed preparing, sowing and rolling after sowing and fertilization with chemical fertilizers; fertilization with chemical fertilizers, rolling before sowing, sowing and rolling after sowing. Compared to traditional technologies, new technologies and technological sequences for improving the degraded grasslands, require reduced fuel consumption and labor, with a lower number of aggregate passes.

Keywords: grassland farming, technology, total reseeding, specific equipment, feed quality

1. Introduction

The technological solutions and specific agricultural machinery for improving the permanent grasslands by total renovation presented in this chapter meet the general objective of the Grassland Science to enhance pastoral heritage by increasing total feed production and quality, with an optimal conversion into animal products, in accordance with a good agricultural practice characterized by the harmonization between economic and social development, biodiversity conservation and environmental protection.

The very different ecological conditions in which the grasslands are located, as well as the socio-economic changes that have led to a certain stage of degradation, require an integrated and interdisciplinary approach in order to develop new solutions for rational management of pastoral heritage, to achieve higher quantities of healthy animal products, to conserve biodiversity and with a reduced ecological impact.

These technologies are consistent with achieving the target regarding the adaptation of the permanent grassland reseeding technologies, specific to each stationary area conditions and implementation of some specific equipment for mechanization the technological sequences in grassland farming.

It is also intended that the proposed technological solutions eliminate or limit the effect of external restrictive factors, so that on the pastures a high fodder production with a high nutritional value is achieved.

For this purpose, the final decision on establishing the technology for improving a degraded grassland area must be taken after an analysis of the limiting factors, the state of degradation, the stationary conditions, the endowment level of the agricultural holding and the possibility of access for agricultural equipment.

Traditional technologies, within are used in conventional farming machines and new technologies, when are used the specific machinery for grassland farming, are analyzed in comparison.

2. Purpose of technological solutions

The productivity of the grasslands is directly influenced both the environmental conditions: these surfaces are located in very different stationary area conditions, usually occupying areas unsuitable for other crops, the poor physics-chemical properties of the soil, the orography of the land or the insufficient temperature with too short a vegetation period from higher altitudes and other causes, and as well as the activities of man and his animals: abandonment, weed control, improper maintenance and use, water imbalance, pollution, etc.

The implementation of the most appropriate technological sequences for the improvement of permanent grasslands and specific agricultural machinery is based on establishing a favorable interaction on the successful use of natural resources, between grasslands ecosystems improved by total renovation and animal husbandry systems.

It is absolutely necessary that before deciding the appropriate improvement solutions and technologies, the causes of the degradation of permanent grassland must be previously determined, because the application of any solution to improve the sward without removing the degradation causes, leads to some good results, valid only on short time.

In accordance with these requirements, the purpose of these technological solutions consists in:

- adaptation of technologies for reseeding permanent grasslands, specific to each stationary area conditions, to achieve sustainable agricultural systems, with minimal effects caused by climate change and economic optimization of technological sequences for obtaining and utilizing the grassland forage;

- increasing the nutritional value of the grass carpet, which ensures a balanced and efficient feeding of different categories of animals, especially from bovine and ovine species, in order to obtain healthy animal products and welfare;

- promoting some specific agricultural machinery for mechanization of grassland farming in condition of a lower specific fuel consumption, labor force number of aggregate passes and implicitly lower costs.

3. Grasslands suitable for improvement by total reseeding method

This grassland improvement solution consists in a complex of works for the total replacement of old vegetation with valuable species and perennial mixtures of grasses and perennial legumes by reseeding.

On the other hand, creating the grassy carpet on the degraded areas, is the simplest and most economical solution to combat soil erosion and improve its physics-chemical properties [1–5].

The improvement of degraded grasslands by reseeding method is the main technology, which is applied on grasslands with an advanced degree of degradation, as well as the poorly productive ones [6].

Within category of degraded and poorly productive grasslands can be mentioned [1–5]:

- grasslands with degraded vegetal carpet;

- grasslands with small productions (less than 4 t/ha green mass);

- grasslands with a degree of vegetation cover below 60%;

- poor quality grasslands, invaded by hillocks (**Figure 1a**), species with low forage value and weeds (over 25–30% of vegetation cover degree, **Figure 1b**);

a b

Figure 1.
Grasslands invaded by molehills, woody vegetation (a) and species with low forage value and weeds (b).

Figure 2.
Grasslands resulting from the destruction of large hillocks and high density.

- grasslands from which the non-valuable woody vegetation was completely cleared (including removing stumps and roots);

- grasslands resulting from the destruction of large hillocks and high density per unit area (more than 25%, **Figure 2**);

Reseeding with species, grasses and mixtures of valuable grasses and legumes is also done in the following cases:

- intensive grasslands after the end of the economic cycle of use (4–5 years);

- grass and perennial legume seed production;

- the establishment of fodder crops, which are introduced in crop rotation on arable lands;

- the establishment of recreational areas and sports fields, etc.

- a rational, ecological and economic solution to bring back abandoned lands in a sustainable agricultural system (grassland rehabilitation).

4. Factors influencing the solutions for improving degraded grasslands

In determining the most appropriate measures to improve degraded grasslands, special attention should be paid to the major influence of the following factors [2, 3, 7–14]:

- quality, the degree of coverage with old vegetation and the thickness of the old greensward;

- soil characteristics;

- area, altitude, exposure, slope and ground orography: unevenness and erosion stage;

- subsequent destination of the improved grassland (pasture, hayfield or mixed etc.);

- level of logistics equipment of the agricultural holding for mechanization of grassland farming;

- financial possibilities of the agricultural holding.

All of the above factors are important, but some of them still need to be given a higher attention.

The analysis of the soil characteristics is made on the basis of the pedological study and the agrochemical mapping of the grassland. From the pedological study as well as on the basis of the agrochemical mapping of the soil the degraded grassland, which are obligatory in this situation, result: the useful edaphic volume of the soil; the thickness of the fertile soil layer and the level of surface erosion; rate of amendment and fertilization; the type, texture and load capacity of the soil that influence the mechanization variants used.

The location area, the altitude, the slope and the surface exposure have a decisive importance in terms of the species and mixtures of forage plants indicated for improvement, respectively on the optimal working period. It is very important to know that the slope of the land is a restrictive factor in the application of measures to improve degraded grasslands, due on the one hand to the restrictions on anti-erosion protection of these areas and on the other hand to the slope size of the recommended of operation limits of agricultural aggregates [7, 8].

The level of logistics equipment of the agricultural holding is one of the decisive factors for implementing the technological sequences of technology. Depending on it, different mechanization variants are established [7, 8]. Also, the financial possibilities of the agricultural holding are decisive in the application of measures to improve these areas [7, 8]. This is because funds are needed for the purchase or rental of specific machines, for fertilizers, seeds, fuels, for mechanical works, for labor remuneration etc.

For providing optimal conditions for seed germination, for the growth of seedlings and their root system, with the ultimate goal of developing a dense vegetation carpet, the best solution will be decided in accordance with the following: adequate tillage system for the destruction of old vegetation, the period of preparation of the germination bed and sowing, basic fertilization, seed mixture, agricultural machinery and equipment for sowing and post-sowing management.

In conclusion, for the successful establishment of a productive grassland by total reseeding must meet the following minimum requirements:

1. Old sward has as small coverage as possible to reduce competition for sown seeds. If it is necessary to do this by work prior to sowing;

2. Severe destruction of old vegetation before sowing. This can be done by mowing, grazing or chemical treatment;

3. Control of perennial existing weeds before sowing;

4. Improving soil characteristics, such as correction of acidity and/or level of nutrient supply, which limit plant growth;

5. Carefully choose the right soil type; avoid heavy and stony soils that are the most difficult;

6. The characteristics of the soils prepared for sowing correspond to the agro technical requirements of the sowing operation (good seedbed conditions, soil will be well crushed and rolling);

7. The correct use of agricultural machinery and equipment appropriate to the various stationary area conditions;

8. Reseeding should be made at period of the year when soil moisture allows rapid installation of new sward (avoid sowing in mid-summer when soil moisture will be limited); if sowing is made in the late summer-early autumn season, the deadline is mid-August -September 1st (especially for areas with a temperate continental climate, specific to Central Europe);

9. Weed control as soon as possible; pest control if they are a problem - snails, for example;

10. Where possible, perennial mixtures of grasses and perennial legumes should be composed of competitive, fast-growing species and varieties, adapted to different stationary conditions;

11. Establishing the most appropriate solutions for the improvement of degraded pastures in accordance with individual circumstances and with a low impact on the environment;

12. Target objective: the existence of a number of approximately 6,000 seedlings/ m^2, in the spring of the year after sowing [15].

5. Farm works and specific agricultural machinery systems necessary for reseeding the grasslands

When determining the type of farming work to be applied on a pasture, the production potential of the grass carpet is a very important criterion, but it is not the only one. The slope of the land limits the degree of mechanization and involves restrictions on some operations that could cause the erosion process. The grasslands located on slopes over 17^0 (30%) no tilled [16]. Also excluded from tillage, no considering their productive level, pastures located on shallow soils with rock fragments on the surface, with groundwater below 50 cm depth and those with a protective role (ravines, gullies etc.) [3, 16].

Improving meadows by reseeding includes the following groups of farming works:

- to create optimal conditions for seed germination, establishment and a good plant growth;
- itself sowing operation;
- grassland farming maintenance after reseeding.

To achieve the optimal conditions for establishment and a good plant growth, the following works are necessary: elimination of excess moisture, combating erosion and landslides, cleaning of hillocks and worthless vegetation, correcting the soil reaction (acidity and alkalinity), fertilizing, preparing the land for sowing. In general, these works are included in pastoral development projects and require agricultural machinery powered by high energy sources, usually used for sward renovation by surface works and other agricultural crops. That is why in this chapter will not be presented the technological sequences and the agricultural equipment used for their

realization. In the following this paper will only focus on the farm works and technical systems necessary for seedbed preparing, sowing the grassland fodder plants and grassland maintenance after reseeding.

5.1 Introductory knowledge regarding the choice of the optimal variant for sowing the grassland fodder plants

The degraded grasslands, recommended for improvement by the method of reseeding are located in very different stationary conditions, starting from the plain area to the mountain area. Adding to this diversity of pedoclimatic conditions, the mode of utilization and the degree of grassland productivity, which can also be very different, results the special importance that must be given to the establishment of species and varieties that are components of grass mixtures.

5.1.1 Choice of species and structure of seed mixtures

A mixture of fodder plants consists of grasses and perennial legumes. The percentage of participation in the mixture of perennial grasses is 60–80%, and that of perennial legumes is 20–40% [2, 3].

In the composition of the seed mixtures are chosen those species that correspond to the stationary area conditions (climatic and soil conditions etc.), the method of cultivation and utilization of pasture, with a high capacity of competition and forage value. These conditions can be met only on the basis of knowledge of climate and soil requirements, suitability for different use system and the nutritional value of the main species of grasses and perennial legumes of grasslands.

For choosing perennial grass and grass species and varieties for composition of a seed mixtures, the following should be taken into account:

1. Duration of use of the grass carpet;

2. How to use the reseeded grassland: grazing, mowing or both; environment protection, biodiversity conservation;

3. The intensity degree of sward utilization related to fertilization rate, animal species and stocking rate, cutting and storage type for preservation;

4. Climate and soil conditions; the possibility of special conditions, such as: disease, drought or disappearance due to frost;

5. Compatibility of species and varieties of perennial grasses and legumes in relation to the optimal harvest time for a superior fodder quality (hay, silo, semi-hay);

6. Compatibility of species and varieties of perennial grasses and legumes in order to obtain optimal fodder productions and qualities.

The large number of new varieties, with different qualities, allow the realization of mixtures compatible with the pedoclimatic conditions specific to each location and how to use later.

Recently, multi-species seed mixtures have been recommended, the so-called complex mixtures, especially for grassland used extensively and for the ecological reconstruction of degraded lands.

5.1.2 Season of sowing

In all areas of the country, spring sowing is a complete success, as early as possible, when agricultural machinery can move in the field and when the temperature does not fall below 0°C (during the nights). On the lands and in the years with sufficient humidity, sowing can be done at the end of summer-beginning of autumn, respectively at the end of August-beginning of September.

In areas with irrigation possibilities, the most recommended sowing time is late summer and early autumn.

5.1.3 Sowing distance

In general, for all mixtures of grassland fodder plants and perennial fodder crops, the inter-row distance is 12–15 cm. In areas and years with sufficient rainfall, mixtures of meadow fodder plants and perennial fodder crops such as alfalfa, red clover can also be sown by broadcasting variant. This sowing method has the advantage of a better ground cover and a more uniform distribution of the nutrition space for each sown plant. That is why it is very successfully applied in the case of park areas, sports and landscape beauty etc.

5.1.4 Sowing depth

Sowing depth varies depending on seed size and on water content of the soil. In the case of mixtures, the sowing depth is conditioned by the seed with the smallest dimensions. Thus, white clover and timothy seeds and mixtures containing these species shall be sown to a depth of 1–2 cm, and other seeds and mixtures to a depth of up to 2.0–2.5 cm, except for sainfoin which sown depth is of 3.5–4.0 cm. In the case of broadcasting method, the sowing depth of 1.0–1.5 cm is ensured by the rolling work before and after sowing by special construction rollers, for a better seed contact with the soil moisture.

5.1.5 Seed rate

In general, perennial grasses and legumes, when used as feed, are seeded in a mixture, this leading to a high quantity and quality of fodder. The exception is alfalfa and red clover, which are also grown in pure crops.

The species and mixtures of different species of perennial grasses and legumes are chosen according to the climate and soil conditions, their productive potential, their forage value, the way they respond to fertilization and the suitability for the desired mode of exploitation.

When sowing recreational areas, special mixtures are used, which meet specific requirements such as: appearance, shade resistance, treading resistance, regeneration after mowing etc. For sports fields, perennial grass species resistant to trampling are chosen, with a low high, which are well regrown and resistant to repeated mowing.

The calculation of the sowing rate of each Q_{si} species participating in the mixture is made with the following relation [8]:

$$Q_{si} = k_s \times S \times q_i \times \frac{100}{V_{ui}}, \text{in [kg]} \quad (1)$$

in which:

- S is the size of sowing surface, in [ha];
- q_i is the rate of sowing for i species for each ha, in [kg/ha];
- V_{ui} represents the useful value of the seed, is made with the following relation:

$$V_{ui} = \frac{P_i \times G_i}{100} \text{ in } [\%], \tag{2}$$

where: P_i represents the purity of the seed of species i, in [%], and G_i represents the germination of the seed of species i in [%], according to the quality certificate;

- k_s is a super unit coefficient that takes into account possible seed losses through handling, administration, etc. Usually we take k_s = 1.05–1.10.

The total mixture sowing rate $\boldsymbol{Q_s}$ is determined by the relation:

$$Q_s = \sum_{1}^{n} Q_{si}, \text{ in [kg]}, \tag{3}$$

where n represents the number of species composing the mixture of seeds.

5.2 Farm works and technical systems necessary for seedbed preparing

The reseeding methods depend by local area stationary conditions, especially the circumstances of the land to be cultivated, such as:

a. degraded grasslands with deep layer of fertile topsoil and thin grass sward;

b. degraded grasslands with deep layer of fertile topsoil and deep grass sward;

c. degraded grasslands with thin layer of fertile topsoil and deep grass sward;

d. degraded grasslands with thin layer of fertile topsoil and thin grass sward;

e. grasslands affected by erosion phenomenon;

f. grassland, fodder or grass and forage legume seed crops established in arable land.

5.2.1 Degraded grasslands with deep layer of fertile topsoil and thin grass sward

For destructing the old vegetation, firstly it is recommended harrowing by two perpendicular passages with the help of medium weight disc harrow. After the disc tillage, the plowing is done at a working depth of 18–22 cm. On slopes higher than 9^0 (16%) plowing is performed with reversible plows. The destruction of the old sward can also be performed with heavy weight disc harrows, performing, in this case, two perpendicular passes. Proper soil leveling must be carried out before or at the same time as the germination bed is prepared. A special importance will be

given to the leveling of the land in the case of the establishment of the seed production fields. This is performed on the diagonal of the parcel, using either special graders or leveling blades (bars, rails etc.) mounted on the germination bed preparation aggregates. The seedbed preparing is made with light (15–20 daN/disc) and medium weight disc harrows (20–30 daN/disc) or with rotary harrows. The preparation of the germination bed is finalized with total tillage cultivators, unless the rotary harrows were used. The working direction for the preparation of the germination bed is on the diagonal of the surface. Before sowing, as well as after sowing, the soil is rolled with a ring roller, possibly ballasted.

By using complex aggregates or combined agriculture machinery, two or more works can be performed simultaneously, which allows reducing energy consumption and limiting the degree of environmental pollution etc.

5.2.2 Degraded grasslands with deep layer of fertile topsoil and deep grass sward

The first agricultural works consist of cutting at a low height carried out with the rotary cleaning machine (rotary toppers) with a vertical rotor or a horizontal rotor, equipped with articulated knives and a floating linkage for better contour following. Destruction of the old sward and seedbed preparing can be done in several ways, namely:

- by a milling at a depth of 6–8 cm, using total agricultural milling machines with "L" shaped knives. Next, plowing, leveling, preparing the germination bed and rolling are performed the same as in the previous point;

- with heavy disc harrows, making two perpendicular passes. The preparation of the germination bed is done with harrows with medium or light weight discs and with combined tillage cultivator. Leveling is performed by mounting a leveling blade behind the disc harrows. Rolling before and after sowing is performed with ring rollers;

- by rotary milling to a depth of 7–8 cm, using agricultural milling machine with total soil processing. The preparation of the germination bed and the sowing is done with the combined machines of total rotary milling and sowing, in which case this operation is perpendicularly on the first pass, and the working depth is 12–13 cm. It is recommended to allow an interval of 10–14 days between the two passes to dry the processed soil.

Complex aggregates can also be used in this situation, which perform two or more operations in a single pass, allowing the reduction of the number of passes, fuel consumption and the level of environmental pollution.

5.2.3 Degraded grasslands with thin layer of fertile topsoil and deep grass sward

Soil cultivation can be done through two technological variants, respectively with or without the use of herbicides. In the first way, for the destruction of the old degraded grass carpet total herbicide is used, by operating the spraying machines for total herbicide. Herbicide operation is carried out in spring or summer two weeks before tillage. After two weeks, the old vegetation is lightly cutting with the grassland cleaning machines. The destruction of the old sward and the preparation of the germination bed can be made using the heavy weight disc harrow, the light disc harrow, the combine soil cultivator and the roller.

If it is not sprayed, a cutting at a low height of the non-valuable vegetation is made previously using rotary cleaning machines. The control of the old vegetation

and seedbed preparing is made in two perpendicular passes of the rotary milling machine equipped with "L" shaped knives for the total processing. The first pass is made at a depth of 6–8 cm with the adjustment of the speed rotation to the maximum. The second passage, recommended to be done after 10–14 days, is performed at a depth of 10–12 cm.

Another variant with low specific consumption consists in destroying the old sward by rotary milling operation to a depth of 6–7 cm, followed by seedbed preparing and sowing, works that are made with the combined rotary tiller-drill machines of total milling and sowing, perpendicular to the first pass, the working depth being of 10–12 cm. Between the first and second pass, to allow the old cultivated soil become dry, an interval of 10–14 days is recommended.

Also if the herbicides are not used, the destruction of the old vegetation and the preparation of the germination bed can be made by two perpendicular passes with heavy disc harrows, followed by medium disc harrows, the combined cultivator and the roller with the ring roller, but the quality of the work, even after the execution of a high number of repeated operations (both with the heavy disk and with the medium one) it is inadequate (degree of incorporation, control of the old sward and soil tillage are unsatisfactory).

5.2.4 Degraded grasslands with thin layer of fertile topsoil and thin grass sward

In the case of these meadow areas, depending on the endowment of the holding, the following variants are recommended:

Option 1: the destruction of the old sward and the preparation of the germination bed can be achieved by two perpendicular passes using heavy disc harrow, followed by 2–3 passes with the medium weight disc harrow, by combined cultivator and the ring roller.

Option 2: control of the old sward is performed with heavy disc harrows by two perpendicular passes. At the second pass, leveling is done by mounting a leveling blade behind the disc harrows. Simultaneously rolling before and after sowing and sowing are operated with special machines for sowing grassland fodder plants.

Option 3: control of the old sward, preparation of the germination bed and sowing are performed in a single pass, in this variant grassland rotary tiller-drill machines are used.

5.2.5 Grasslands affected by erosion phenomenon

In variant of grasslands with a low slope, up to $10–12^0$ (17,5-21,0%), and with a colluvium horizon, the soil is mobilized by superficial plowing to a depth of 14–16 cm with reversible plows or by repeated operations with light or medium weight disc harrow [3, 16].

After plowing, the land is cultivated with light disc harrows with the combined seedbed preparation devices equipped with a leveling blade and with the ring roller.

In the case of lands with slopes between 12 and 22^0 (21 and 40%) the control of the old vegetation can be done in the following ways:

- repeated passes with medium disc harrows;
- superficial plowing with reversible plows;
- rotary milling to 6–8 cm depth with rotary cultivator equipped with knives for total processing.

The preparation of the germination bed on the plowed lands is further achieved with rotary harrows or with medium disc harrows, with the combined seedbed preparation devices with leveling blade and with the ring roller.

The preparation of the germination bed on the rotary milling lands is done by a second passage at a depth of 8–10 cm with the rotary cultivator with "L" shaped knives, for total processing, followed by the ring roller.

Rolling before and after sowing and sowing can be carried out simultaneously with special machines for sowing grassland fodder plants.

The use of combined rotary tiller-drill machines allows the realization of the old vegetable carpet control, the seedbed preparation, the sowing and the rolling after sowing by one pass.

On slopes greater than 7^0 (12%), the farm works must be carried out on the level curves, strictly observing the following technological requirements: on long slopes, where soil erosion process is favored, the operations necessary for grassing must be done in alternative lanes parallel to the level curves. Uncultivated strips are to be operated on next year when the first series is already established. The width of the lanes varies depending on the slope as follows: on a slope of $7–9^0$ (12–16%) between 30 and 40 m; on a slope of $9–14^0$ (16–25%) between 20 and 30 m; on a slope of $14–18^0$ (25–32%) between 12 and 20 m; respectively on a slope of $18–22^0$ (32–40%) between 7 and 12 m [1, 7, 8, 16, 17].

The machines and equipment are operated with special slope tractors (4WD tractor, equipped with double wheels or caterpillars).

5.2.6 Grassland, fodder or grass and forage legume seed crops established in arable land

The land is plowed to a depth of 20–22 cm with the plows, then the germination bed is prepared with rotary harrows or with light or medium weight discs harrow followed by the combined cultivator with leveling blade and rolling with the ring roller. The preparation of the germination bed has to be executed on the diagonals of the parcel. Particular attention will be paid to leveling the ground, which can be realized either before the preparation of the germination bed, or at the same time. For leveling before the seedbed preparation, the trailed graders are used, and for the leveling during the seedbed preparation, leveling blades mounted behind the germination bed preparation aggregates are used.

By using complex or combined farming aggregates, two or more operations can be performed simultaneously, which allows reducing energy consumption and limiting the degree of environmental pollution etc. [1, 8, 17, 18]. Thus, by using the combined rotary tiller-drill machines, the soil processing, the preparation of the seedbed, sowing and rolling after sowing are performed in a single pass.

On the other hand the use of the special sowing machines for grassland fodder plants, the seeding, and the rolling before and after sowing is simultaneously performed. Also, by forming and using compatible complex farming aggregates, which can perform in a single pass several works for example: plowing simultaneously with the fertilizer; old sward control simultaneously with the seedbed preparation etc., considerably reduces fuel consumption, the level of environmental pollution and production costs.

5.3 Technologies and specific agricultural machinery systems necessary for reseeding the grassland

In this subsection are presented the different reseeding methods for improving the degraded grasslands, located in different stationary area conditions.

For improving the degraded grasslands it is necessary to adopt optimal technological solutions so as to obtain the desired results, avoiding technical errors. Traditional technologies, within are used in conventional farming machines and new technologies, when are used in specific machinery for grassland farming, are analyzed in comparison.

The differences of necessary of specific fuel consumption, labor force and number of aggregate passes between usual and new technologies have been determined.

According to the stationary area conditions, are recommended to apply the most appropriate alternatives to improve the degraded grassland by reseeding method, taking into account also the endowment of farm. Therefore there are situations when for mechanization of grassland farming is used conventional agricultural machinery.

Classic technology for reseeding the degraded grasslands use aggregates providing the realization of one operation by one pass machine, such as: liming; spreading the fertilizers; destruction of the old grass sward; seedbed preparing; rolling before sowing; sowing; rolling after sowing [8, 17].

The new technological solutions are based on utilization of complex farming aggregates, using specific equipment and machines.

Depending on work conditions, to improve the degraded grassland by reseeding method, new solutions of mechanization technology using complex aggregates which provide the realization of 2, 3 or 4 operations by one pass machine are used.

Thereby specific fuel consumption, labor force and involving the number of passes are lower.

New technology for reseeding the degraded grasslands use complex aggregates providing the realization of two or more operation by one pass machine, as following:

- destruction of the old sward and liming;
- seedbed preparation and fertilization with chemical fertilizers;
- rolling before and after sowing, sowing of fodder grass plants;
- destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers;
- clearing of non-value vegetation, of mole-hills and fertilization with chemical fertilizers;
- clearing of non-value vegetation, of mole-hills and lime spreading;
- destruction of the old grass sward and seedbed preparing;
- fertilization with chemical fertilizers, rolling before/after sowing, sowing of fodder grass plants.

For a guaranteed success, it is important that each technological sequence corresponds to the agronomic requirements and has a beneficial effect on the environment.

In **Table 1** there are presented the new technology for reseeding the degraded grassland.

In **Figure 3** are presented the total fuel consumption, necessary labor force and the number of machine passes, both for usual variants and new technological

solutions. The data are given for each situation in which the degraded grasslands are located (a, b, c, d, e and f).

The graphs were drawn based on the data obtained during the experimental results for the variants of using the usual agricultural equipment and using the specific agricultural equipment for mechanization of grassland farming [8, 9].

Operation	Recommended aggregate*
0	1
a. Degraded grassland with deep layer of fertile topsoil and thin grass sward	
a.1. Variant 1	
Destruction of the old sward and liming/ fertilization	 Wheel tractor of 74 kW + Heavy disc harrow GDG 2,7 type +Equipment for chemical fertilization EF 2,5 type**
Seedbed preparation and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary harrow 2,5 m with + Equipment for chemical fertilization EF 2,5 type
Rolling before/after sowing, sowing of fodder grass plants	 Wheel tractor of 74 kW + Special machine for sowing fodder grass plants MSPFP 2,5 type**
a.2. Variant 2	
Destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary tiller-drill machine improved MCT 2,5 M type** + Equipment for chemical fertilization EF 2,5 type

Operation	Recommended aggregate*
0	**1**
b. Degraded grassland with deep layer of fertile topsoil and deep grass sward	
b.1. Variant 1	
Cleaning of non-value vegetation, of mole-hills and fertilization with chemical fertilizer	 Wheel tractor of 74 kW+ Machine for cleaning the grassland MCP 2,5 type + Equipment for chemical fertilization EF 2,5 type
Destruction of the old sward and liming/ fertilization	 Wheel tractor of 74 ... 88 kW + Heavy disc harrow + Equipment for chemical fertilization EF 2,5 type
Seedbed preparation and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary harrow with + Equipment for chemical fertilization EF 2,5 type
Rolling before/after sowing, sowing of fodder grass plants	 Wheel tractor of 74 kW + Special machine for sowing fodder grass plants MSPFP 2,5 type
b.2. Variant 2	
Cleaning of no value vegetation, of molehill and administration of the amendments	 Wheel tractor of 74 kW + Machine for cleaning the grasslands MCP 2,5 + Equipment for chemical fertilization EF 2,5 type

Operation	Recommended aggregate*
0	1
Destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary tiller-drill machine improved MCT 2,5 M type + Equipment for chemical fertilization EF 2,5 type
c.Degraded grassland with thin layer of fertile topsoil and deep grass sward	
Cleaning of no value vegetation, of molehill and administration of the amendments	 Wheel tractor of 74 kW + Machine for cleaning the grasslands MCP 2,5 + Equipment for amendment administration EF 2,5 type
Destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers	 Wheel tractor of 74 ... 88 kW + Rotary tiller-drill machine improved MCT 2,5 M type + Equipment for chemical fertilization EF 2,5 type
d. Degraded grassland with thin layer of fertile topsoil and thin grass sward	
Destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary tiller-drill machine improved MCT 2,5 M type + Equipment for chemical fertilization EF 2,5 type
e. Grassland affected by erosion	
Destruction of old grass sward and seedbed preparation	 Wheel tractor of 59 kW + Medium or light weight disc harrows in aggregate with fixed toothed harrows

Operation	Recommended aggregate*
0	**1**
Sowing of fodder grassland plants and rolling before and after sowing	 Wheel tractor of 74 kW (80 HP) + Special machine for sowing fodder grass plants MSPFP 2,5 type
f. Grassland, fodder or grass and forage legume seed crops established in arable land	
f1. Variant 1	
Tillage for preparing the seedbed	 Wheel tractor of 88 kW + Medium weight disc harrow
Rolling before/after sowing, sowing of fodder grass plants	 Wheel tractor of 74 kW + Special machine for sowing fodder grass plants MSPFP 2,5 type
f2. Variant 2	
Destruction of the old grass sward, seedbed preparing, sowing of fodder grass plants, rolling after sowing and fertilization with chemical fertilizers	 Wheel tractor of 74 kW + Rotary tiller-drill machine improved MCT 2,5 M type + Equipment for chemical fertilization EF 2,5 type

**When the operations are carried out on the grasslands affected by erosion and also located on slope conditions are required following the indications provided in chapter 5.2, letter e.*
***Specific agricultural equipment for grassland farming designed, made and tested in different stationary area conditions by the Grassland Research Institute from Brasov, Romania.*

Table 1.
New technological variants for mechanization of grassland improvement by reseeding method [8, 9, 19].

In according with working conditions and degradation stage of grassland, the data presented in **Figure 3** demonstrates the following:

- total fuel consumption for usual alternatives varies between 27,0 and 86,8 l ha^{-1};
- total fuel consumption for new mechanization solutions range between 17,4 and 65,4 l ha^{-1};
- the fuel consumption economy range between 9,6 and 21,4 l ha^{-1} in favor of the new technologies;
- consumption of labor force for usual variants of mechanization varies between 3,9 and 12,1 man hour ha^{-1};
- consumption of labor force for new mechanization technologies range between 1,7 and 5,7, man hour ha^{-1};
- the labor force economy is between 2,2 and 6,4 man hour per ha, in favor of the new technologies;
- the number of aggregate passes for usual solutions varies between 5 and 10;
- the number of aggregate passes for new mechanization solutions range between 1 and 4.

6. Grassland maintenance after reseeding

The maintenance farming works are different depending on the sowing season, respectively spring or summer-autumn [1, 3, 8, 17].

6.1 Grassland reseeded in spring

At an interval of 3–4 weeks after sowing it is necessary to control weeds. This can be made in two ways, namely: chemically by selective herbicide, respectively mechanically by mowing and evacuation of mowed plants from the field. The choice of herbicides is made according to the weed species that need to be controlled based on the catalogs of plant protection products. For administration, the recommended doses and the application phase indicated by the manufacturer must be within the rules, strictly observing the environmental protection norms.

Mowing and removing from the field must be done in a good weather condition and in a short time so as not to damage the new established sward.

The following cycles are mowed or grazed, depending on the destination for which the respective grassland was reseeded.

In autumn it is necessary to remove excess grass by grazing sheep for a short time.

6.2 Grassland reseeded in end of summer-early autumn

In this situation, weed control by mowing operation is no necessary, as weeds are usually annual plants that disappear with the arrival of winter and do not have the necessary time for seed production. In the spring, the state of sown field is

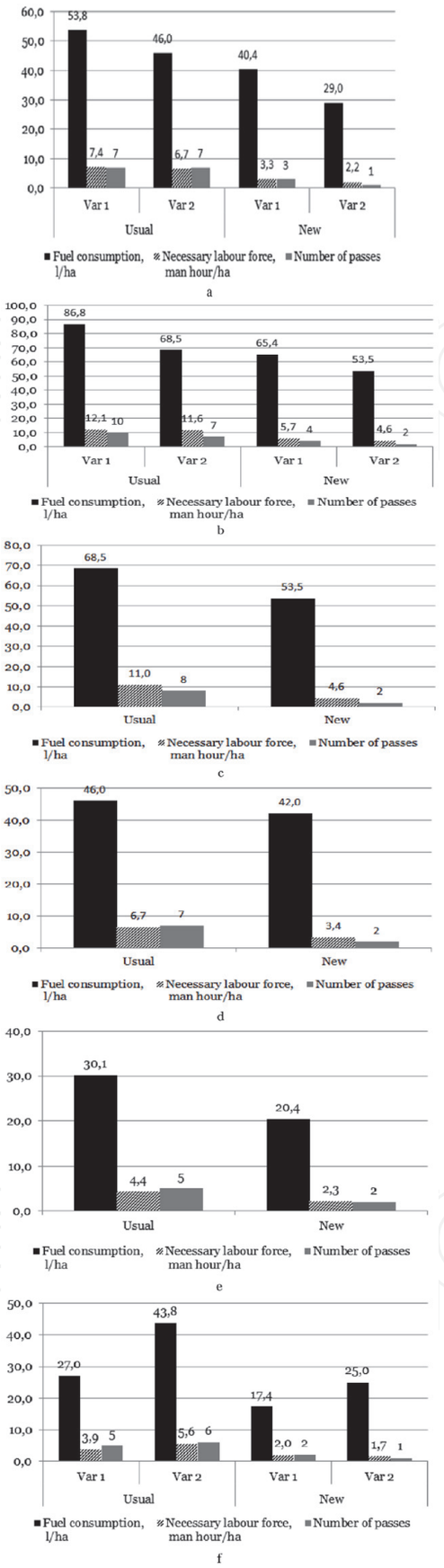

Figure 3.
Comparative of fuel consumption, necessary labor force and number of passes between new and usual technology, depending on local stationary area conditions (a, b, c, d, e and f): a-degraded grasslands with deep layer of fertile topsoil and thin grass sward; b-degraded grasslands with deep layer of fertile topsoil and deep grass sward; c- degraded grasslands with thin layer of fertile topsoil and deep grass sward; d-degraded grasslands with thin layer of fertile topsoil and thin grass sward; e-grasslands affected by erosion phenomenon; f-grassland, fodder or grass and forage legume seed crops established in arable land.

monitored and only if its weeding is found, weed control is used, proceeding as in the same way of the spring season. The other farm works recommended for grassland sown in spring remain valid.

7. Conclusion

Permanent grasslands cover a very large percentage of the world's surface and are of great importance to the environment, so their sustainable management is a widespread problem of interest and is not limited to those who exploit them.

For this purpose, the elaboration of technological solutions and the promotion of specific agricultural machines for improving the degraded pastures through total renovation, was based taking into account the causes of degradation, the diversity of stationary area conditions, destination (economic function, protection, landscape beauty etc.) and the specific equipment used for mechanization of these farming works.

It was also intended that the proposed technological solutions eliminate or limit the effect of external restrictive factors, so as to ensure a high feed production and a high quality, based on the causes of degradation, the diversity of seasonal conditions in which these areas are located, destination (economic function, protection, landscape etc.) and the specific equipment used for the mechanized execution of the works.

To establish these technologies, the results of multidisciplinary research were combined (agrochemistry, pedology, pratotechnics, soil processing works, fertilization, weed control, disease and pest control, soil analysis etc.). Based on the use of experimental results, zonal technologies and specific technical systems were promoted, focusing a sustainable development of agriculture in conditions of multifunctionality, biodiversity and stability of environmentally friendly yields.

In comparison to usual variants, the new mechanization technologies for improving the degraded grasslands by reseeding method, for different stationary area conditions, involve a reduced fuel comsumption of 10–46% and labour forces of 49–67% with a smaller number of agricultural aggregate passes of 3–8 units.

By lowering fuel consumption, necessary labour force and the number of machine passes, new technological solutions of mechanization of work for improving degraded grasslands by reseeding method have a reduced environmental impact, environment pollution (air, water, soil) is less, inputs are lower and costs decrease proportionally, within 15–30% [9].

The promotion of the most suitable technological sequences for improving the grasslands must be based on establishing a favorable interaction between the grassland ecosystems improved by total renovation and the animal breeding systems. To be successful these initiatives, with good results, avoiding technical errors, optimal technological solutions are necessary to adopt.

Therefore, in general, the human factor, through his activities, has a great responsibility for rehabiliting these degraded areas, by practicing the sustainable agricultural systems, to protect the environment.

8. Final conclusion

Using science and technology it can make grassland farming more profitable, agreeable and sustainable.

DOI: http://dx.doi.org/10.5772/intechopen.99403

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